MODIS DATA SYSTEM STUDY

TEAM PRESENTATION

February 24, 1989

AGENDA

1. Update to MODIS Mailing List
2. Scenario Illustrating Algorithm Development and Implementation
3. Specific Scenario Illustrating Field Experiments
4. MODIS Data Product and Algorithm Fact Sheet

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Scenario Illustrating Algorithm Development and Implementation

Algorithm development and implementation will be occurring both prior to launch and after launch. In this scenario, we list some of the steps that may be encountered in a typical developmental program with a typical time line.

An algorithm developer will have several points of contact within MIDACS. First will be the science team leader and other science team members. At science team meetings and through the Science Management Plan, all developers will be kept informed of what algorithms are being developed. A second point of contact is the Science Data Processing Support Team (SDPST). The SDPST will be polling the team members to determine if there are certain algorithms that they should develop so that several team members will not unnecessarily duplicate each others work. The SDPST will examine the computer code developed by the team members and, if necessary, will modify it so as to most efficiently use the computer architecture of the CDHF. The SDPST will also keep the team members informed of EosDIS programming standards and EosDIS standards for data formats. They will aid the science team members in meeting Eos goals.

T in this scenario is the algorithm implementation date and possibly the launch date.

T minus 5 years: The science team member receives sufficient computing resources from the MODIS Project Office so that he can start algorithm development.

T minus 2 years to T minus 2 months: A prototype algorithm is developed and debugged by a science team member. Validation studies such as those discussed in the team members proposals will be performed during this period. Each team member is assumed at this point to be responsible for acquiring the needed correlative data. Validation study results, source and object codes, and technical reports such as user's guides will be delivered to MIDACS for storage in the DADS. The preliminary version of the algorithm is submitted to the CDHF for timing tests. Computer scientists at the GSFC TMCF node and CDHF (the SDPST) begin examination of the software code and look for methods to increase the efficiency such as vectorization. The SDPST also provides the science team member with some subroutines which aid in his algorithm development, such as some data input/output and plotting subroutines. Finally the SDPST keeps the algorithm developer informed about EosDIS data format standards and programming language standards. The science team member continues to check the accuracy and validity of the algorithm.

T minus 2 months to T minus 1 month: Using lower level MODIS data generated by the CDHF and other Eos and non-Eos data which is routinely required for the processing and using the CDHF computers, the science team member and computer scientists have interacted to increase the code efficiency, with runs requiring

about 1/3 to 1/100 the computer time that the initial code required. No loss in accuracy has occurred and the CDHF computer architecture is fully exploited. It appears that a data product with desired accuracy is being generated by the algorithm. The SDPST team has also aided the team member in defining methods of acquiring other Eos data required for the algorithm to work and in acquiring non-Eos data such as ground truth data, which may be routinely incorporated into the data processing.

T minus 1 month: The algorithm is formally delivered to the CDHF by the science team member, along with all certification and DQA criteria needed for autonomous processing. A proposed Algorithm Release Announcement (ARA) is sent to the team leader. The ARA contains such information as a description of the algorithm, the data products it will generate along with an estimate of their accuracy, the period of time planned for coverage, the area coverage, the version number, references to user's manuals, and references to the pertinent supporting scientific literature. The object of the release announcement is to keep the team leader informed and to allow the team leader to inform IMC and the scientific community at large of MODIS activities.

T minus 1 week: The CDHF automated/expert system processing code is updated to bring the new algorithm on line. The science team leader sends an Algorithm Release Announcement to the IMC, which states the algorithm will be implemented in one week and gives information on what standard data products will be produced. All team members and the Eos Project Office among others will be kept informed this way.

T: The algorithm is applied to Level-1B data and generates a Level-2 product. Browse, metadata, and catalog data are generated. The certification criteria are tested. As explained above, T is the time that the algorithm is actually implemented and may not be the actual launch time. After MODIS is placed in orbit, it may undergo a period of testing known as the activiation period. The calibration of the instrument will be tested and all the algorithms used to generate geophysical parameters will probably be tested intensively. The activation period will last from several weeks to several months and may differ from algorithm to algorithm. Thus the time T may be several weeks to months after the launch. The earlier data and the currently incoming data will need to be simultaneously processed following the official implementation at time T.

T plus 1 day: DQA indicates a change in the algorithm is needed. For the purposes of this scenario, we assume that the initial validation tests indicate a problem exists with the algorithm and that the certification criteria are not being met. The CDHF withdraws the algorithm from routine processing. The defective data are sent to the DADS as uncertified and are only available to the science team.

T plus 2 months: The science team member has located the problem in the code and fixed it. The revised algorithm is resubmitted to the CDHF and the CDHF reinstalls it in its Level-2 processing stream.

T plus 2.2 months: Archival of the geophysical parameter starts since it is now a certified standard product. The science team leader, based upon the most recent validation studies, certifies the algorithm and issues a new Algorithm Release Announcement. Simultaneously, retroactive processing on the backlog of data, taken prior to the implementation of the algorithms, is used to derive the new standard product. The required input data is acquired from the DADS and sent directly to the CDHF for processing at twice the processing rate.

T plus : As the MODIS experiment continues, the scientific algorithm is updated and maintained as required. The maintenance of algorithms is an ongoing aspect of the experiment.

3.3 Specific Scenario Illustrating Field Experiments

This is a specific, hypothetical example of a field experiment that might be supported by MODIS data. This scenario is intended to illustrate how the MODIS science team members will use MIDACS to accomplish the objectives of a coordinated observing campaign.

The field experiment is a three-month campaign to observe the interaction of the Gulf Stream with the Atlantic Ocean. It is assumed that this investigation involves three MODIS team members, the Woods Hole Oceanographic Institute, and the Office of Naval Research. This experiment will combine EOS data with in-situ readings taken aboard ship and by buoys dropped from aircraft. These data will be used to examine two key areas: the dynamic evolution of the vortices created at the margin of the Gulf Stream and, the variation of the various ocean parameters normal to the boundary of the Gulf Stream and the Atlantic Ocean.

3.3.1 Observation Plan

The general scheme is to use MODIS-N nighttime data to observe the edges of the Gulf Stream with 1-km resolution. The MODIS data products will be used to point the HIRIS instrument, direct the cruising on surface vessels, and guide the placement of surface buoys. MODIS-N and -T data will also be required from the daytime passes.

The surface vessel(s) will take data along 10-km tracks normal to the boundary of the Gulf Stream and the Atlantic Ocean. Each vessel will need to know the location and orientation of this boundary. It is assumed that each ship carries a Global Positioning System (GPS) receiver so that the position is known to better than 100 m. The ships will collect water samples for comprehensive analysis.

The vortices will be studied by imaging with MODIS and HIRIS and by dropping buoys into the center of the vortex from a Navy P-3 aircraft. The buoys will be equipped with a temperature sensor and a GPS receiver to track the dynamical evolution of the vortex. After the disturbance dissipates, the buoys will be recovered by a Navy ship.

There will be severe time constraints in this scenario. The MODIS data will be analyzed and used to target HIRIS for the next afternoon. The HIRIS targets must be selected 3.5 hours before the observation is to be made in order to allow time for scheduling and conflict resolution. The data will be collected and sent through TDRSS and the DHC to the CDHF within approximately 3.5 hours of taking the first data. (Note: This may require that TDRSS be scheduled for real-time downloading of the MODIS data from the third of the three orbits.) The team member at the Goddard TMCF node requires a little time to examine the map and decide on the appropriate HIRIS target(s) (e.g., 1.5 hours). This

would require that the CDHF process the data and transmit the result to the TMCF within approximately 3.5 hours.

After selecting the appropriate targets, the MODIS team member will generate a HIRIS observation request. It is assumed that in the HIRIS schedule there is provision for two observations to support this experiment on each of three successive orbits. The MODIS team members need only select the geographic location of the targets and scheduling software will generate all the necessary commands. It is assumed that the HIRIS data can be processed in a normal fashion and that processing instructions will be included in the observation request.

When a new vortex is seen, the team member will transmit a buoy drop request to the Navy. The team member will send a list of one or more new target locations to the Navy and, the Navy operational personnel will decide when and where buoys can be deployed. If there are buoys and a plane available and weather permits, the Navy will dispatch an aircraft which will be able to reach the Gulf Stream in 4 to 6 hours and deploy the buoys.

It is assumed that information on the location and orientation of the boundary will be sent to the surface ships each morning. Each ship will be directed by a scientist onboard in accordance with an overall plan. The operations of the ships will be coordinated by radio conferences between the ships.

Buoy recovery will be done by the Navy. After the vortex has dissipated, the team member will notify the Navy and the buoys will be recovered by either a surface vessel or helicopter. The recovered buoys will be taken to an aircraft carrier and from there back to the staging area.

3.3.2 Experiment Schedule

It is assumed that work on this experiment will begin approximately one year before the first observation. It is further assumed that formal agreement between the various participants has been reached at this time. It is assumed that three months of planning, scheduling, and negotiations between the various agencies results in a preliminary plan and the firm commitment of all the required non-EOS resources.

Six months prior to the beginning of the experiment a preliminary EOS observation plan will be generated. This plan will be sent to the MODIS and HIRIS team leaders and the IWG. Approval by the IWG will be required since there will be a significant EOS resource required for this experiment. After conflict resolution, the resources required for this experiment will be allocated in the long-term plan. It is assumed that the required TDRSS resources will be scheduled at this time.

A significant amount of software development will be required to support this experiment. The software development is scheduled for the period of 3 to 9 months before the experiment.

It is determined that the boundary of the Gulf Stream is most easily observed using the thermal channels of MODIS-N at night. It is likely that sea-surface temperatures will be routinely derived using the thermal channels of MODIS-N combined with ancillary data from other EOS instruments. However, in this scenario it is assumed that only MODIS-N data will be used. It is determined that this will require that a special algorithm be written and implemented. In particular, it is determined that, due to the severe time requirements, it will be necessary to pass the Level-0 data directly from the DHC to the TMCF.

To map the full extent of the interaction region will require 15 minutes of data from three successive orbits. Approximately 150 Mbytes of data will be received for each orbit. Only the portion of the data covering the region of interest will be processed. The processing will be done by a team member at the Goddard TMCF node. The data will be calibrated using previously determined calibration coefficients, and surface temperature calculated. This will be non-standard processing, and algorithms must be developed to accomplish this.

An algorithm will be developed that combines the three orbits and produces a single, geometrically rectified map of sea-surface temperature. The processing will be done on, and the resulting map displayed on, a graphics workstation. The maps will be visually examined to look for new vortices. Another algorithm will automatically determine the position and orientation of the Gulf Stream boundary. (Note: It is assumed that clouds will be visible in the surface temperature map. Determining how to deal with cloud cover will be a significant activity during the software development phase.) This will be a specialized MODIS data product generated within the TMCF.

Approximately one month before the beginning of the experiment the team member generates detailed observation plans for MODIS and HIRIS. By exercising the scheduling software available at the Goddard TMCF, the team member determines that it is possible to download all of the nighttime MODIS-N data in real time. Requesting this service is allowed by the priority level of this experiment and the data are scheduled for real-time transmission to the ground terminal and for forwarding to the DHC and CDHF with no significant delay.

It is determined that the normal daytime and nighttime operation of MODIS is required for this experiment. Therefore, the team member issues a request which locks MODIS in the normal observations mode for the duration of the experiment over the domain (unless a higher priority request comes along). A HIRIS data acquisition request is initiated which gives the observing times and acquisition mode (i.e., channel selection). The HIRIS request

will be updated with pointing information about two orbits prior to the actual observation.

The preliminary request is approved and updated one week and two days prior to the beginning of the experiment.

Finally the experiment begins. The first observation is taken at 11:30 PM Goddard time. The Level-0 data from the first orbit is available at the Goddard TMCF within one-half hour. The data from the third orbit will be available about 3.5 hours later. The team member who is doing the analysis is required to be on duty at about 3 AM. The map will be generated and displayed on a graphics workstation at the Goddard TMCF.

The team member will visually examine the map and will select up to 6 targets for HIRIS. The HIRIS observations will be scheduled by updating the preliminary observations at least two orbits prior to the observation. If less than six targets are selected, one or more of the HIRIS observations will be cancelled.

The team member will prepare messages for the Navy as to whether and where to deploy buoys. A message for the surface ships will be prepared automatically and the team member will only be required to check this message before it is transmitted. The messages will be transmitted by telephone.

All of the data, including the MODIS real-time data, will be processed in the normal fashion. All of the standard products will be produced and available at the DADS in 96 hours. The team members will gain access to their data in the normal fashion by issuing an Archive-Data-Request.

The HIRIS data will be processed through Level-0 and sent to the team member on magnetic tape. The instructions to accomplish this are included in the data acquisition request and no further actions are needed to obtain the data.

The data from the ship board sensors is collected at Woods Hole and sent to the team member on floppy disks. The data from the buoys are collected at the Naval Research Laboratory and sent to the team member on magnetic tape.

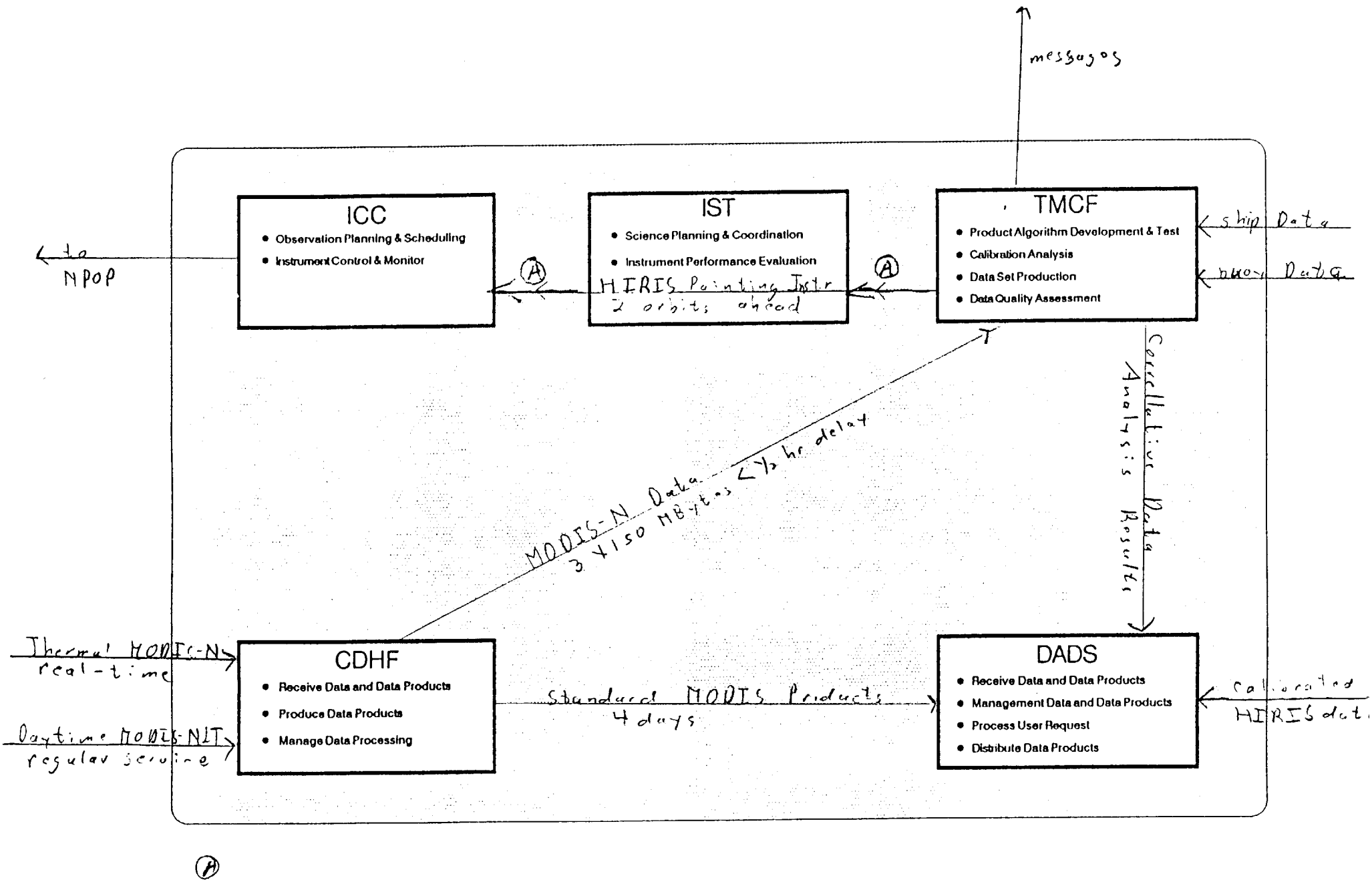
One month after the experiment is over all of the data are in the hands of the team member. The data set is analyzed by several graduate students over the next four years. The team member will be responsible for ensuring that all of the results are properly documented and sent to the DADS.

TABLE 3-1
TIME SCHEDULED for GULF STREAM EXPERIMENT

Pre-experiment Activities	
T - 1 year	Project begins.
T - 9 mon.	Preliminary experiment plan developed. Software development begins.
T - 6 mon.	Observation plan submitted to EOS. TDRSS resources requested.
T - 3 mon.	Software development finished.
T - 1 mon.	Detailed observation requests submitted. TDRSS scheduled.
T - 2 day	Final pre-observation update to schedule.

For Each Day of the Experiment	
T + 4 hours	All nighttime MODIS data received at TMCF.
T + 7 hours	Data processing done, map display available.
T + 8 hours	Target lists for HIRIS prepared, schedule updated.
T + 10 hours	Messages sent to Navy and surface ships.
T + 12 hours	Daytime HIRIS and MODIS observations begin.
T + 15 hours	Buoys deployed.

After the Last Day of the Experiment	
T + 4 days	All of the MODIS and HIRIS data available in DADS.
T + 1 mon.	All ship and buoy data received by team members.
T + 4 years	Analysis finished. All results available in active archive.


messages
ICC
Observation Planning & Scheduling
Instrument Control & Monitor
to NPOP
IST
Science Planning & Coordination
Instrument Performance Evaluation
HIRIS Pointing Instr
2 orbits ahead
TMCF
Product Algorithm Development & Test
Calibration Analysis
Data Set Production
Data Quality Assessment
ship Data
HIRIS Data
Correlative Data
Analysis Results
MODIS-N Data
3 Viso MB-ytes
½ hr delay
Thermal MODIS-N
real-time
Daytime MODIS-NIT
regular service
CDHF
Receive Data and Data Products
Produce Data Products
Manage Data Processing
Standard MODIS Products
4 days
DADS
Receive Data and Data Products
Management Data and Data Products
Process User Request
Distribute Data Products
Calibrated
HIRIS data
A
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MODIS DATA PRODUCT AND ALGORITHM FACTSHEET

DATA PRODUCT NAME: Fast Delivery Sea Surface Temperatures (deg. C)

ALGORITHM(S) NAME:
MACHINE:
OPERATING SYSTEM:
LANGUAGE:

DEVELOPER: Dr. Ian J. Barton

SCIENTIFIC DISCIPLINE(S): Oceans/physical properties

LEVEL AND/OR CATEGORY: Level 3, standard, on demand only

SPATIAL COVERAGE: Global

SPATIAL RESOLUTION: 0.5 km.

TEMPORAL COVERAGE: Launch onwards (on demand only)

TEMPORAL RESOLUTION: Hourly (or once per satellite pass)

INPUT DATA:
NPOP-1 PLATFORM DATA: TBD
MODIS-N ANCILLARY DATA: TBD
MODIS-T ANCILLARY DATA: TBD
MODIS-N CHANNELS: Thermal channels TBD
MODIS-T CHANNELS: None
OTHER MODIS DATA PRODUCTS: None
OTHER EOS INSTRUMENTS: AMRIR
(AMSU, SCATT, ALT, etc. for validation studies)
NON-EOS DATA: TBD
GROUND-TRUTH DATA: Field campaigns by Dr. Barton

DATA VOLUME ON-LINE REQUIRED: With a global ocean surface area of 3.6×10^8 km.^{2}, at 0.5 km. resolution, there are 1.44×10^9 bins. At 2 bytes/bin and two MODIS thermal channels per temperature determination, data volume is 5.8×10^9 bytes/day.

ESTIMATED DAILY DATA VOLUME GENERATED: Up to 1.44×10^9 bytes/day or 1.4 GB.

DESIRED DISTRIBUTION MEDIA: TBD

TIMELINESS REQUIREMENTS: Daily (within 96 hours)

ADDITIONAL COMMENTS:
Generated on demand for operational forecasting and other near-real-time applications.

MODIS DATA PRODUCT AND ALGORITHM FACTSHEET

DATA PRODUCT NAME: MODIS Land Surface Temperatures (deg. C)

ALGORITHM(S) NAME: Split-window technique (Prabhakara et al.,1974)
MACHINE: TBD
OPERATING SYSTEM: TBD
LANGUAGE: TBD

DEVELOPER: Dr. Stephen Running

SCIENTIFIC DISCIPLINE(S): Land/biological systems/physical properties

LEVEL AND/OR CATEGORY: On-line input for daily evapotranspiration maps; standard

SPATIAL COVERAGE: North American continent

SPATIAL RESOLUTION: 1 km. (?)

TEMPORAL COVERAGE: Launch to 1999

TEMPORAL RESOLUTION: Daily

INPUT DATA:
NPOP-1 PLATFORM DATA: TBD
MODIS-N ANCILLARY DATA: TBD
MODIS-T ANCILLARY DATA: TBD
MODIS-N CHANNELS: Thermal channels TBD (radiance values)
MODIS-T CHANNELS: None
OTHER MODIS DATA PRODUCTS: None
OTHER EOS INSTRUMENTS: None
NON-EOS DATA: None
GROUND-TRUTH DATA: None

DATA VOLUME ON-LINE REQUIRED: 4.4×10^7 bytes.

ESTIMATED DAILY DATA VOLUME GENERATED: 4.4×10^7 bytes or 0.04 GB (not a DADS product)

DESIRED DISTRIBUTION MEDIA: TBD

TIMELINESS REQUIREMENTS: Generated daily (within 96 hours)

ADDITIONAL COMMENTS:
Algorithm subject to change, based upon other MODIS efforts.

MODIS DATA PRODUCT AND ALGORITHM FACTSHEET

DATA PRODUCT NAME: Single Scattering Aerosol Radiance

ALGORITHM(S) NAME: TBD
MACHINE: 50 - 80 MIPS machine TBD
OPERATING SYSTEM: TBD
LANGUAGE: TBD

DEVELOPER: Dr. Robert H. Evans

SCIENTIFIC DISCIPLINE(S): Oceans/physical/biological

LEVEL AND/OR CATEGORY: Level 3, standard

SPATIAL COVERAGE: Global

SPATIAL RESOLUTION: 1 km. in coastal regions; 4 km. in open ocean

TEMPORAL COVERAGE: Launch onwards

TEMPORAL RESOLUTION: Daily

INPUT DATA:
NPOP-1 PLATFORM DATA: Epheremis
MODIS-T ANCILLARY DATA: TBD
MODIS-N ANCILLARY DATA: TBD
MODIS-T CHANNELS: 17 bands TBD (Level 0 data)
MODIS-N CHANNELS: Visible channels TBD (Level 0 data)
OTHER MODIS DATA PRODUCTS: None
OTHER EOS INSTRUMENTS: Total ozone (GOMR)
Surface wind observations (SCATT-2)
NON-EOS DATA: Global atmospheric pressure (NOAA/Navy)
GROUND-TRUTH DATA: Water leaving radiances (Clark and Smith)

DATA VOLUME ON-LINE REQUIRED: 20 to 50 GB

ESTIMATED DAILY DATA VOLUME GENERATED: 3 to 6 GB (not a DADS product)

DESIRED DISTRIBUTION MEDIA: 2 Mbps dedicated line

TIMELINESS REQUIREMENTS: Within 24 hours of Level 0 data receipt

ADDITIONAL COMMENTS:
This is a supporting data product used to find global water leaving radiances.
It appears all processing will be done on the TMCF and none on the CDHF.

MODIS DATA PRODUCT AND ALGORITHM FACTSHEET

DATA PRODUCT NAME: MODIS-N Calibration Coefficients

ALGORITHM(S) NAME: TBD
MACHINE: Workstation
OPERATING SYSTEM: TBD
LANGUAGE: TBD

DEVELOPER: Dr. Otis B. Brown

SCIENTIFIC DISCIPLINE(S): Calibration

LEVEL AND/OR CATEGORY: Calibration data

SPATIAL COVERAGE: NA

SPATIAL RESOLUTION: NA

TEMPORAL COVERAGE: Launch to 2000

TEMPORAL RESOLUTION: TBD

INPUT DATA:
NPOP-1 PLATFORM DATA: TBD
MODIS-N ANCILLARY DATA: Detector temperatures, blackbody temperatures
MODIS-T ANCILLARY DATA: None
MODIS-N CHANNELS: 26,27,28,30,33,34,35 (Level 0 data)
MODIS-T CHANNELS: None
OTHER MODIS DATA PRODUCTS: None
OTHER EOS INSTRUMENTS: None
NON-EOS DATA: None
GROUND-TRUTH DATA: None

DATA VOLUME ON-LINE REQUIRED: TBD

ESTIMATED DAILY DATA VOLUME GENERATED: 75 MB per series of 48 calibration runs which are performed at TBD intervals.

DESIRED DISTRIBUTION MEDIA: Magnetic media (6250 bpi tapes?)

TIMELINESS REQUIREMENTS: Within 24 hours of Level 0 data receipt

ADDITIONAL COMMENTS:
MODIS-N will also be calibrated by Solomonson, Slater, and perhaps others. Results will need to be coordinated.

MODIS DATA PRODUCT AND ALGORITHM FACTSHEET

DATA PRODUCT NAME: Ground-truth Ocean Parameters

ALGORITHM(S) NAME: TBD
MACHINE: DEC VAX and MicroVAX II
OPERATING SYSTEM: Unix (?)
LANGUAGE: Fortran or C

DEVELOPER: Dr. Dennis K. Clark

SCIENTIFIC DISCIPLINE(S): Oceans/biological/physical

LEVEL AND/OR CATEGORY: Ground-truth data

SPATIAL COVERAGE: TBD

SPATIAL RESOLUTION: Compatible with MODIS data

TEMPORAL COVERAGE: Pre-launch and post-launch periods

TEMPORAL RESOLUTION: TBD

INPUT DATA:
NPOP-1 PLATFORM DATA: None
MODIS-N ANCILLARY DATA: None
MODIS-T ANCILLARY DATA: None
MODIS-N CHANNELS: None
MODIS-T CHANNELS: None
OTHER MODIS DATA PRODUCTS: None
OTHER EOS INSTRUMENTS: None
NON-EOS DATA: None
GROUND-TRUTH DATA: Buoy data (see comments below for list of potential data products); ship tracks

DATA VOLUME ON-LINE REQUIRED: 0.6 GB per year

ESTIMATED DAILY DATA VOLUME GENERATED: 0.002 GB

DESIRED DISTRIBUTION MEDIA: MODIS compatible; tables; plots; maps

TIMELINESS REQUIREMENTS: None

ADDITIONAL COMMENTS:
Potential ground-truth data products are: 1) downwelled spectral irradiance, 2) Upwelled spectral irradiance, 3) water leaving spectral radiances, 4) diffuse attenuation coefficients, 5) photosynthetic active radiation, 6) fluorescence line height, 7) spectral reflectance)or radiance) factor, 8) phytoplankton pigment concentrations, 9) total suspended matter concentration, 10) FLH chlorophyll a concentration, 11) fluorescence quantum efficiency, 12) phaeopigment a concentrations, and 13) primary production.